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Chen

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(54) **HEAT EXCHANGER AND METHOD FOR FABRICATING THE SAME**

(71) Applicant: **INVENTEC CORPORATION**, Taipei (TW)

(72) Inventor: **Chien-An Chen**, Taipei (TW)

(73) Assignee: **INVENTEC CORPORATION**, Taipei (TW)

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(51) **Int. Cl.**

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F28F 3/04	(2006.01)
F28F 3/12	(2006.01)
B23C 3/00	(2006.01)
B23C 3/30	(2006.01)
B21D 31/02	(2006.01)
B21D 53/02	(2006.01)

(52) **U.S. Cl.**

CPC . ***F28F 3/02*** (2013.01); ***F28F 3/048*** (2013.01); ***F28F 3/12*** (2013.01); *B21D 31/02* (2013.01); *B21D 53/022* (2013.01); *B23C 3/00* (2013.01); *B23C 3/30* (2013.01); *B23P 15/26* (2013.01); *Y10T 29/4935* (2015.01); *Y10T 409/303752* (2015.01)

(58) **Field of Classification Search**

CPC B23P 15/26; F28F 225/12; F28F 225/16; F28F 3/02; F28F 3/042; F28F 3/048; F28F 3/12; F28F 13/06; F28F 2215/08; F28F 2215/12; F28F 2215/00; Y10T 29/4935; Y10T 29/49366; Y10T 29/49389

USPC 165/80.4, 80.5

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,106,014 A *	10/1963	Brick et al.	....	228/118
5,309,983 A *	5/1994	Bailey	....	165/80.3
6,422,307 B1 *	7/2002	Bhatti et al.	....	165/185
7,219,719 B2 *	5/2007	Gerard	....	165/166
2012/0014066 A1 *	1/2012	Morino et al.	....	361/707
2012/0227952 A1 *	9/2012	Yoshihara et al.	....	165/185

FOREIGN PATENT DOCUMENTS

WO WO 2011061779 A1 * 5/2011

* cited by examiner

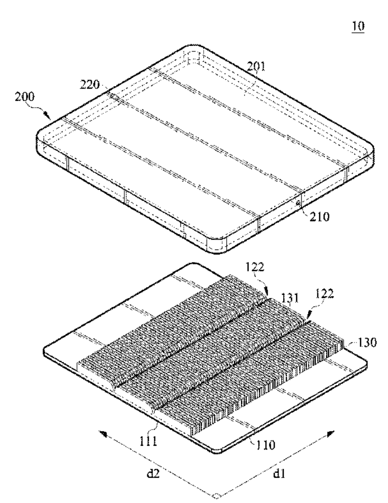
Primary Examiner — Christopher Besler

(74) *Attorney, Agent, or Firm* — Locke Lord LLP; Tim Tingkang Xia, Esq.

(57) **ABSTRACT**

A heat exchanger comprises a base portion and a plurality of fins. The fins are disposed on the base portion in parallel along a processing direction. Each fin has a processing surface far away from the base portion. The processing surfaces sunken to form at least one groove, and the groove extends along a grooving direction which intersects with the processing direction. Furthermore, each fin has two upper valley sides at the groove, and the two upper valley sides connect the processing surface. The two upper valley sides and the processing surface form an obtuse angle. The structure of the heat exchanger can prevent processing waste filling in the passages between fins.

6 Claims, 13 Drawing Sheets



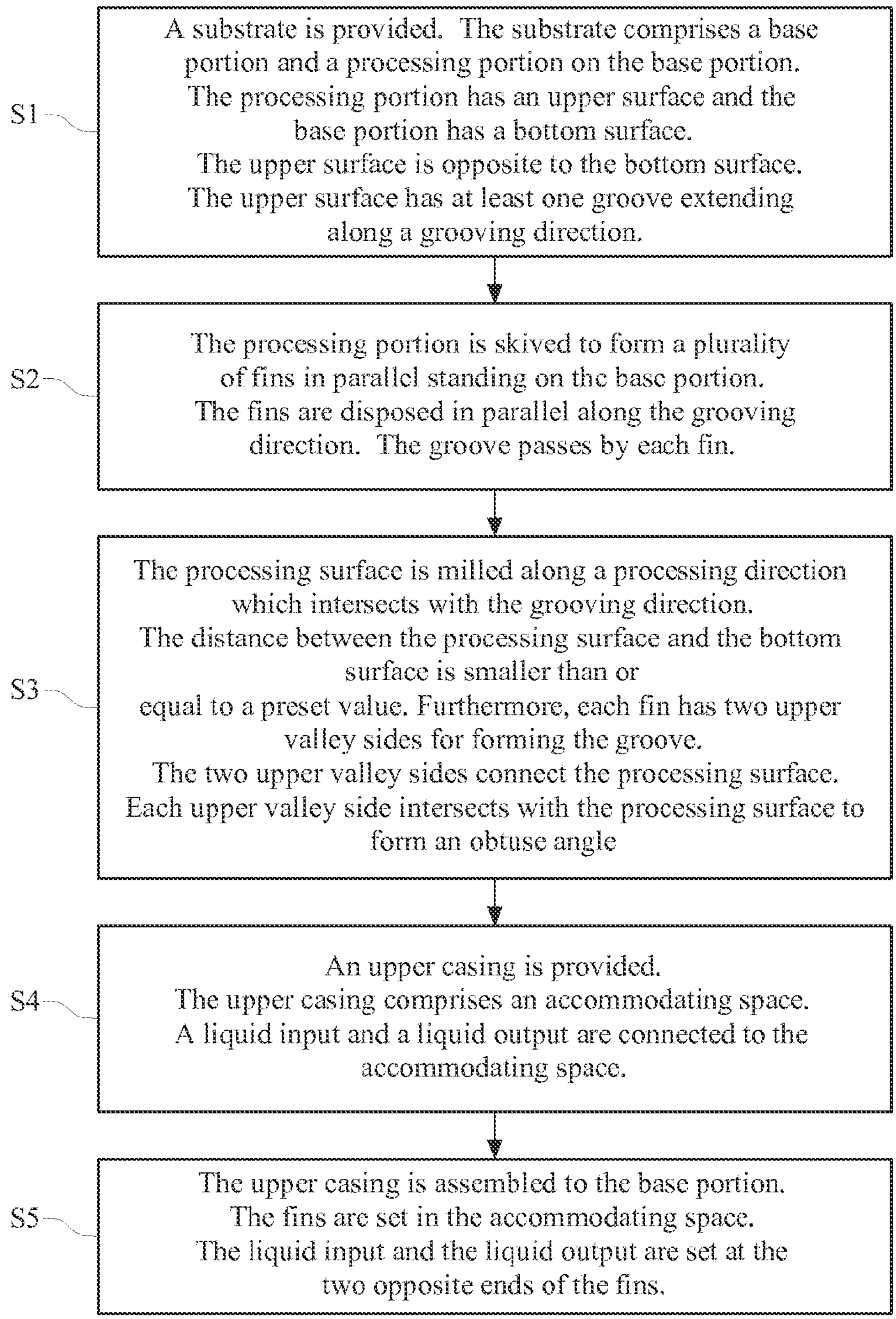

S1
A substrate is provided. The substrate comprises a base portion and a processing portion on the base portion. The processing portion has an upper surface and the base portion has a bottom surface. The upper surface is opposite to the bottom surface. The upper surface has at least one groove extending along a grooving direction.
S2
The processing portion is skived to form a plurality of fins in parallel standing on the base portion. The fins are disposed in parallel along the grooving direction. The groove passes by each fin.
S3
The processing surface is milled along a processing direction which intersects with the grooving direction. The distance between the processing surface and the bottom surface is smaller than or equal to a preset value. Furthermore, each fin has two upper valley sides for forming the groove. The two upper valley sides connect the processing surface. Each upper valley side intersects with the processing surface to form an obtuse angle
S4
An upper casing is provided. The upper casing comprises an accommodating space. A liquid input and a liquid output are connected to the accommodating space.
S5
The upper casing is assembled to the base portion. The fins are set in the accommodating space. The liquid input and the liquid output are set at the two opposite ends of the fins.

FIG.1

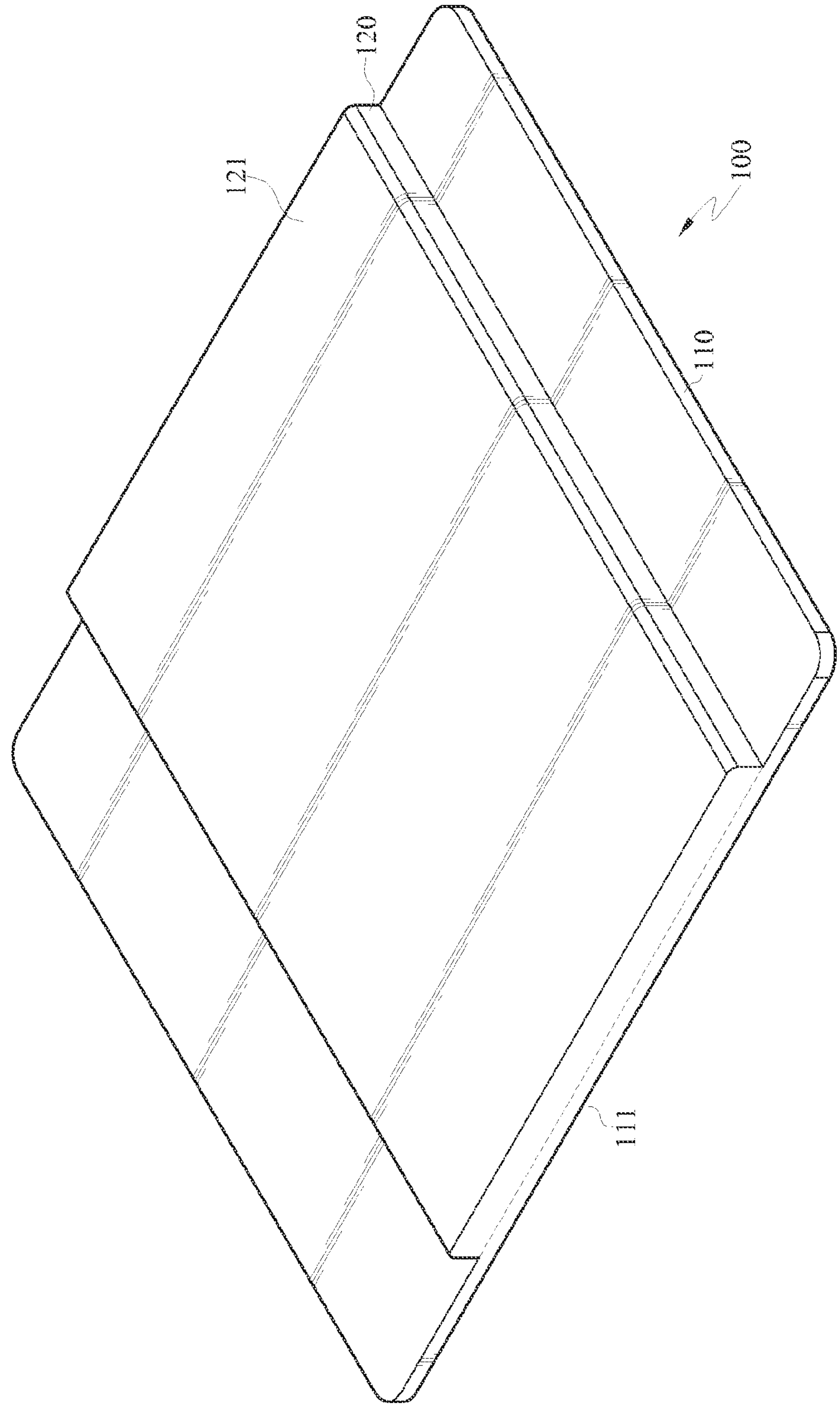


FIG.2A

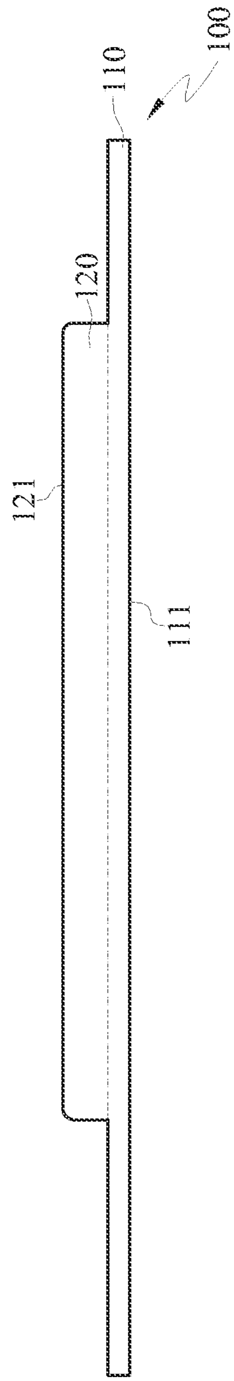


FIG.2B

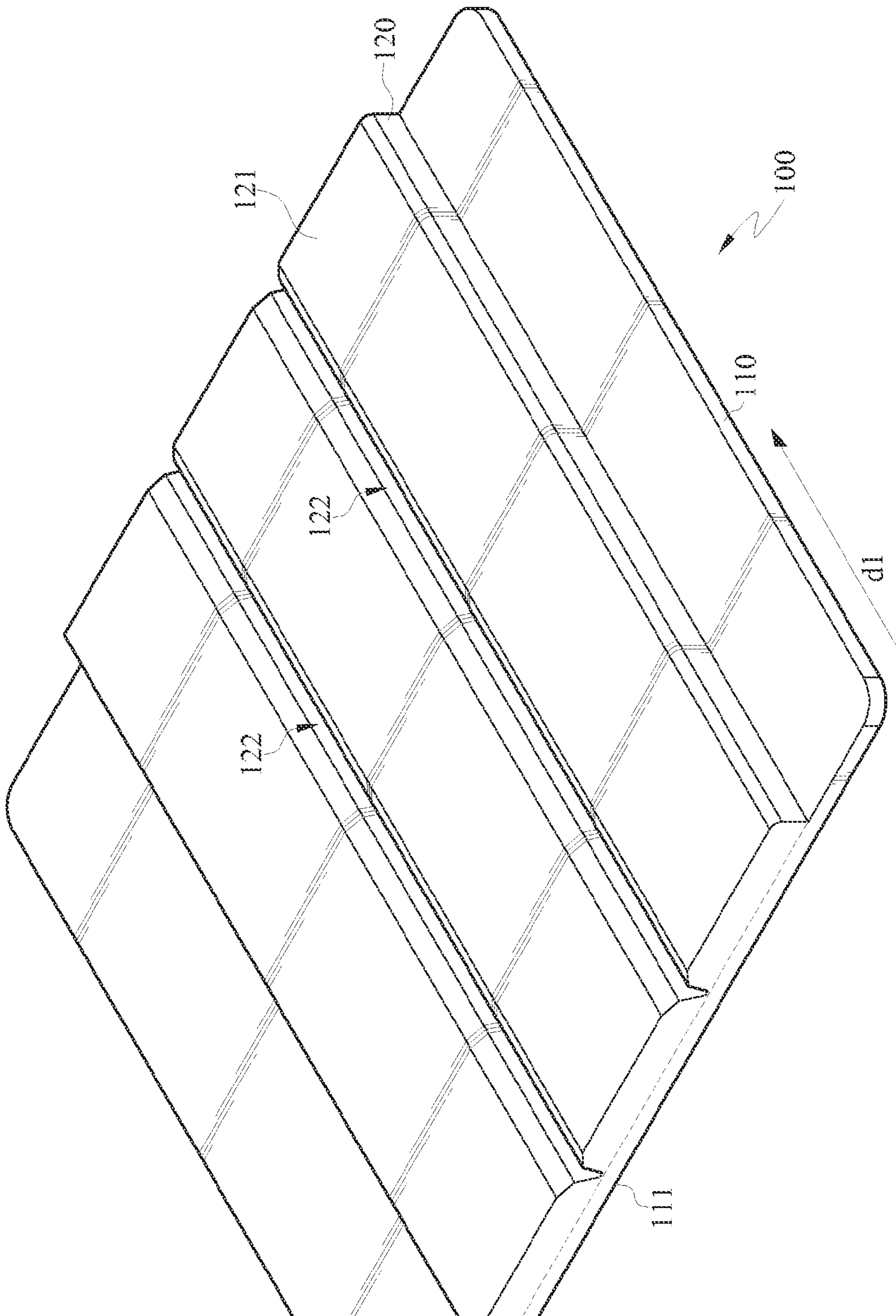


FIG. 3

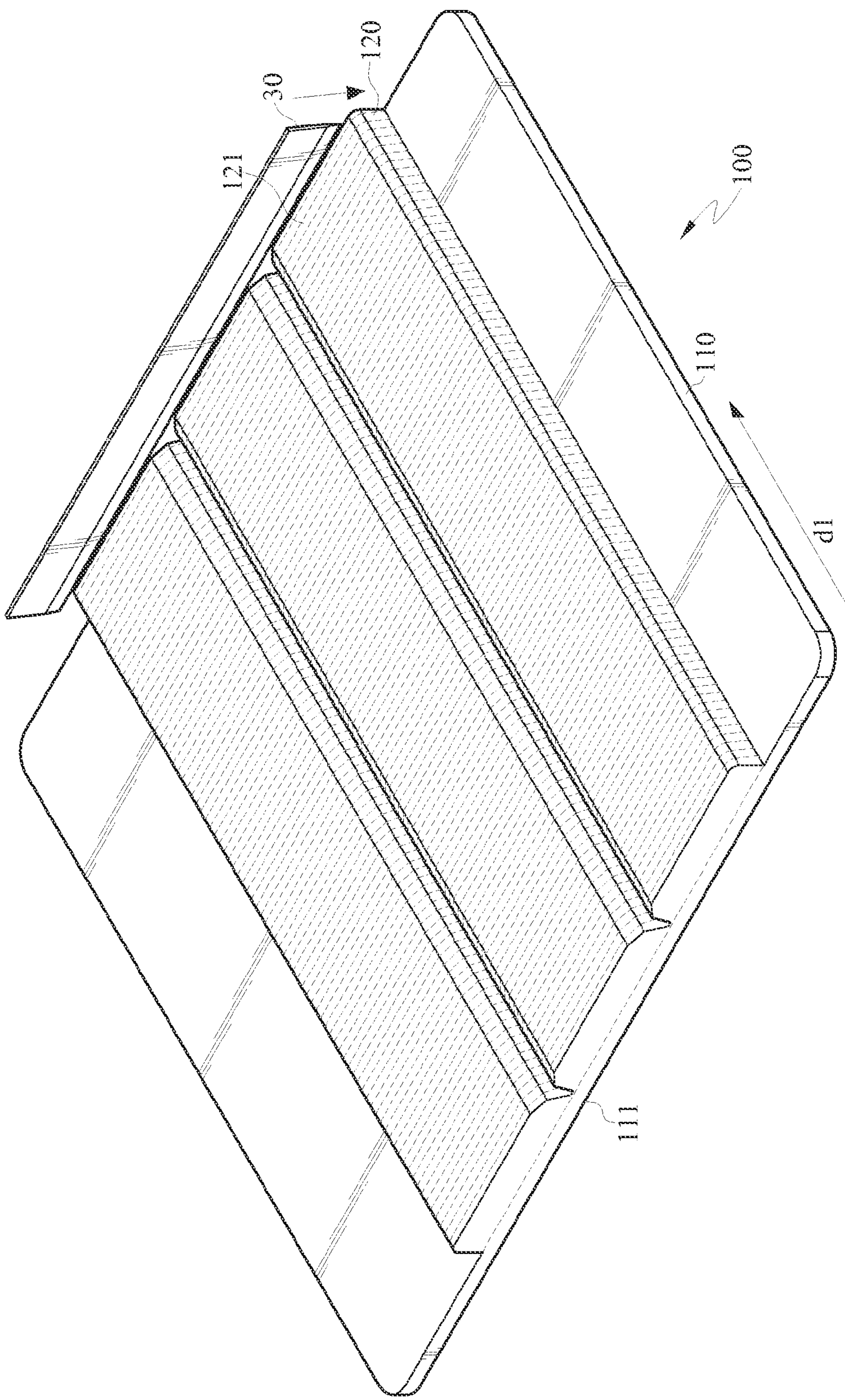


FIG.4A

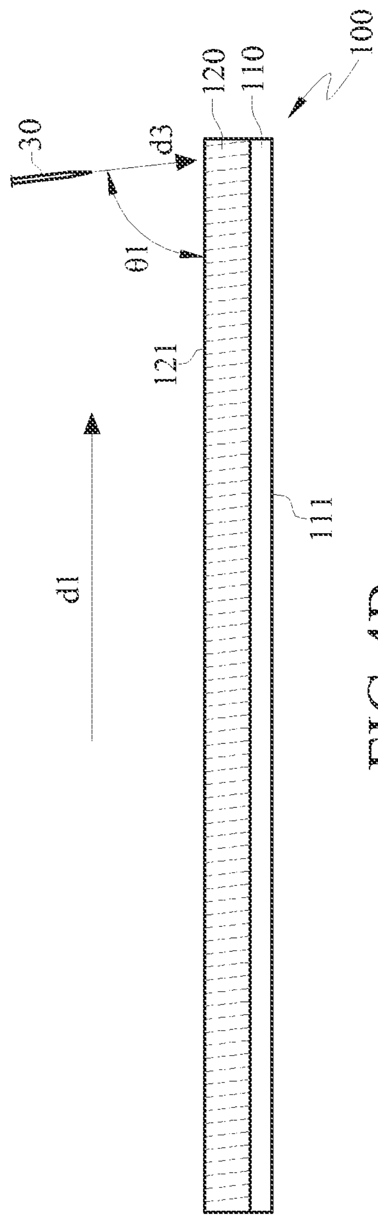


FIG.4B

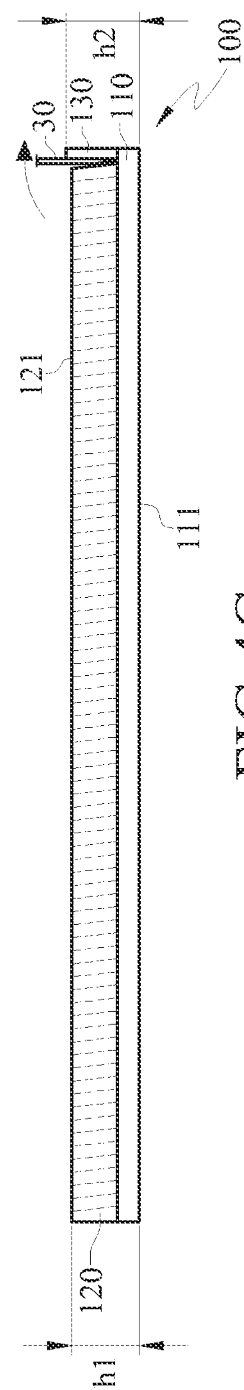


FIG.4C

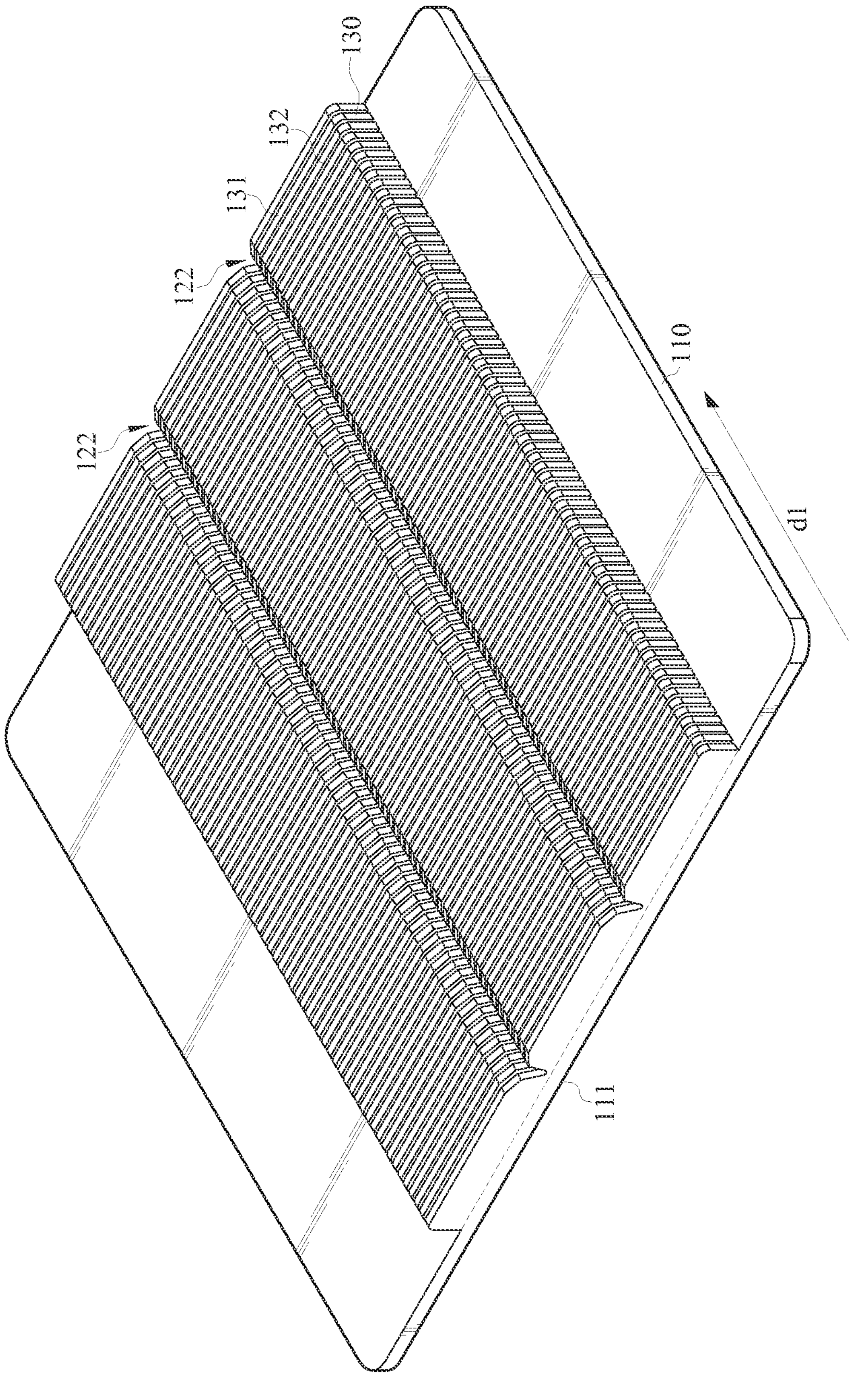


FIG.5A

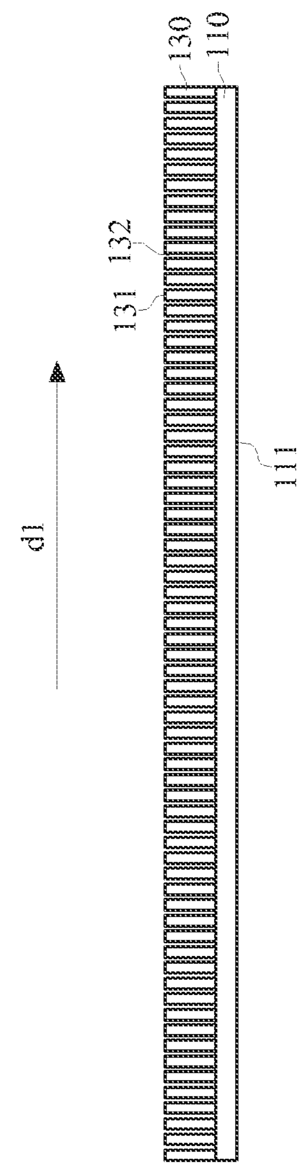


FIG.5B

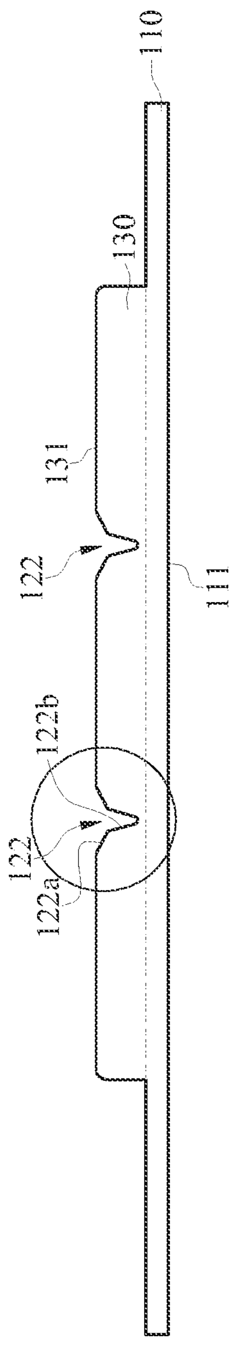

110
130
131
122
111
122b
122
122a

FIG.5C

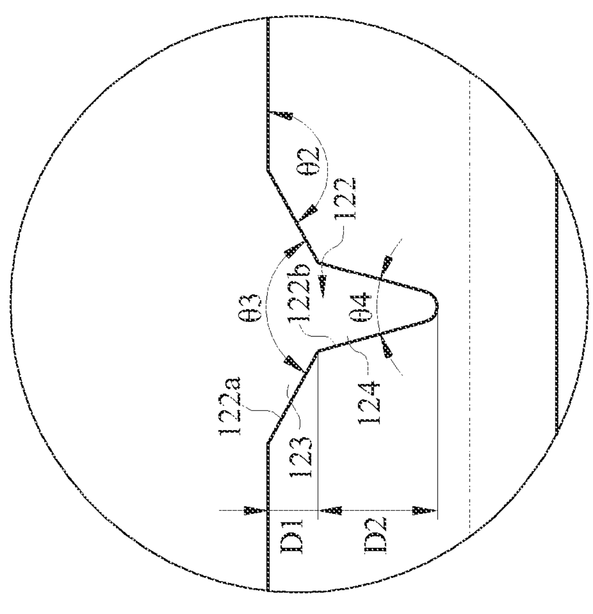

θ2
122
122b
θ3
θ4
124
122a
123
D1
D2

FIG.5D

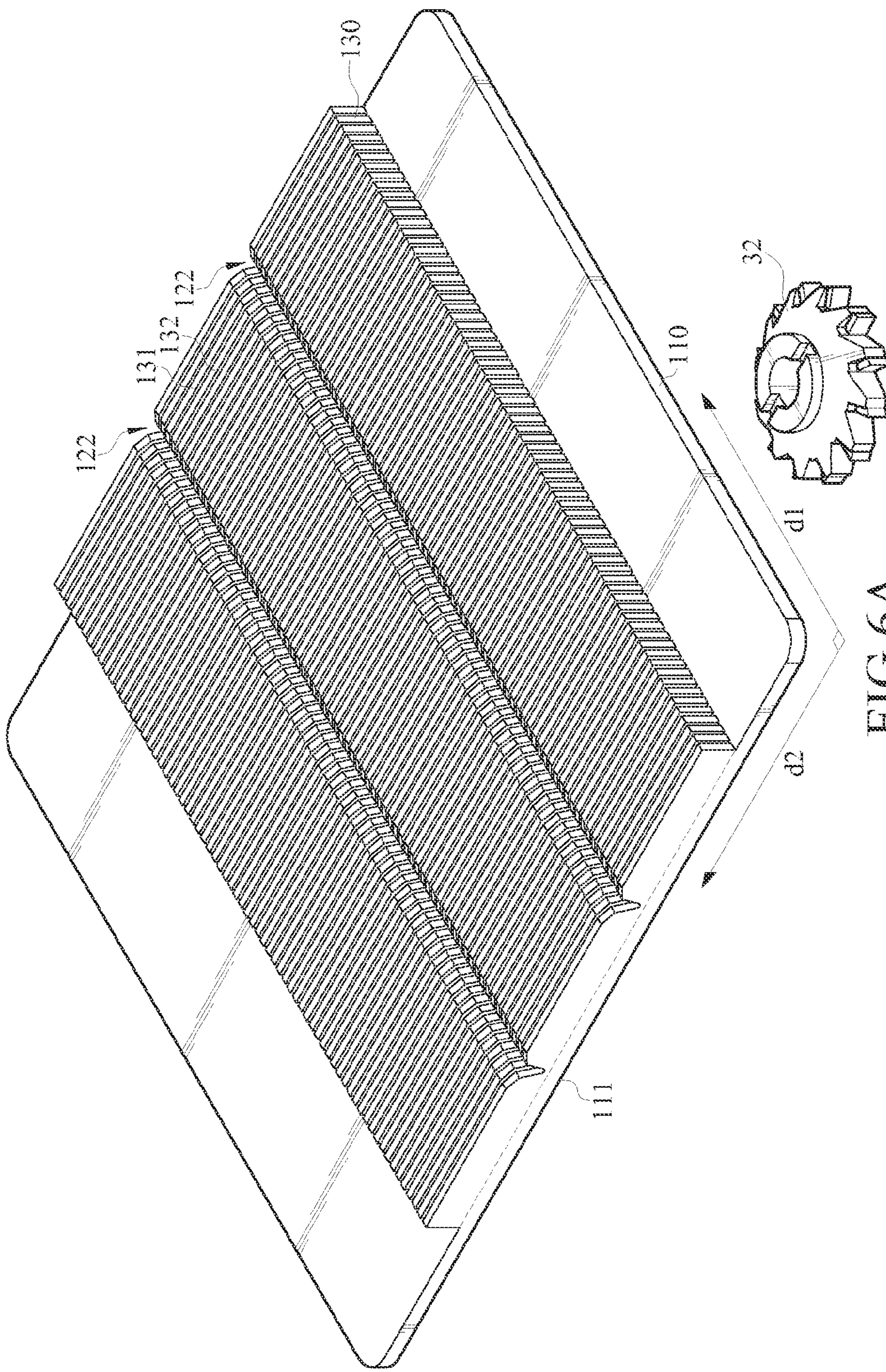


FIG.6A

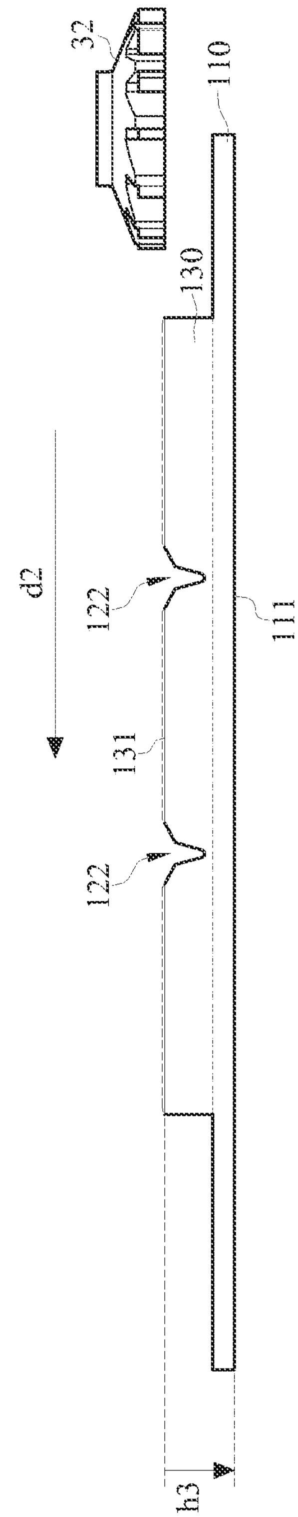


FIG.6B

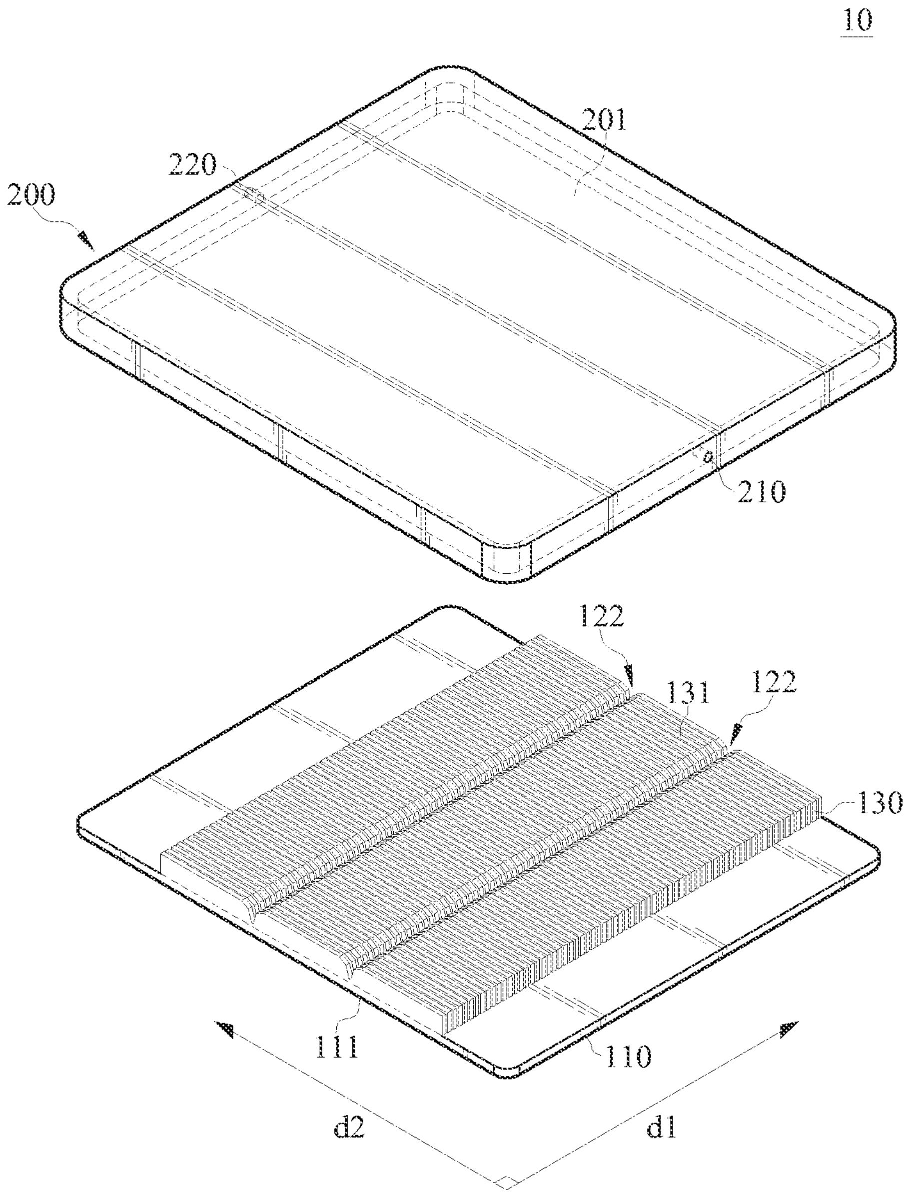


FIG.7A

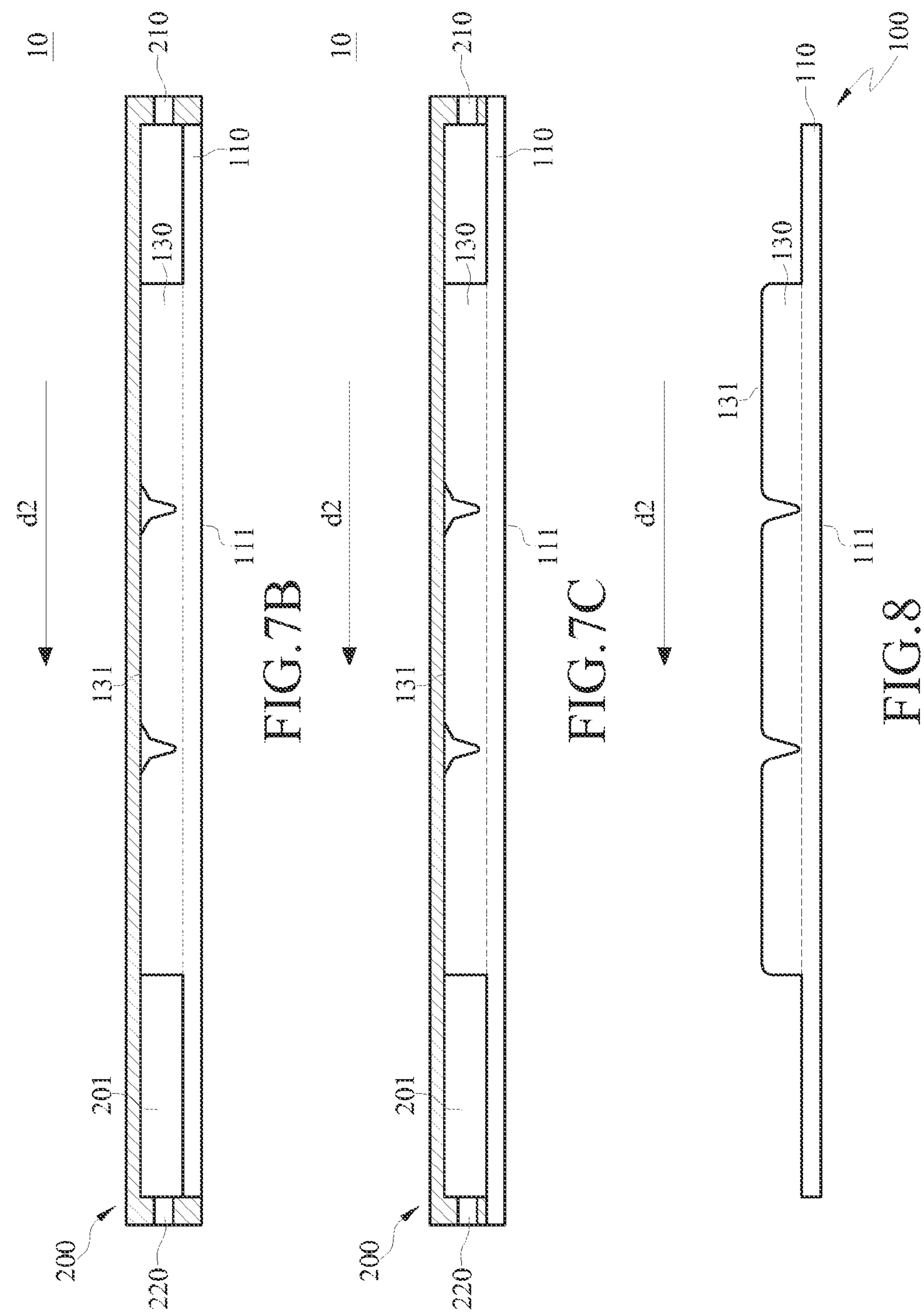


FIG.7B

FIG.7C

FIG.8

HEAT EXCHANGER AND METHOD FOR FABRICATING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This non-provisional application claims priority under 35 U.S.C. §119(a) on Patent Application No(s). 101109181 filed in Taiwan, R.O.C, on Mar. 16, 2012, the entire contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Technical Field of the Invention

The disclosure relates to a heat exchanger and method for fabricating the heat exchanger, and more particularly to a heat exchanger having a plurality of fins and method for fabricating the heat exchanger.

2. Description of the Related Art

A heat dissipation module for a cabinet server often uses air-cooling heat dissipation mode. The operation of air-cooling heat dissipation is to set heat dissipation fins on various heat sources and to set corresponding heat dissipation fans in the casing of the cabinet server. The heat convection forced by the heat dissipation fans can dissipate heat generated by the heat sources. In this heat dissipation manner, the environmental temperature of the casing is very high because after the airflow brought by the heat dissipation fans takes way heat, the environmental temperature will be increased. Therefore, during the heat dissipation for the cabinet server, the directions for dissipating heat needed to be uniformed so that a cold channel and a hot channel are formed to control the environmental temperature. If environmental temperature of equipment room is not well controlled, it is very difficult to decrease the temperature of the cabinet server. With area of the equipment room getting larger, the density of servers is getting much greater. The design and management of environmental temperature, cold channel and hot channel become increasingly complicated.

The liquid-cooling heat dissipation module provides another manner for dissipating heat. The liquid-cooling heat dissipation module does not use air to decrease temperature, and thus it will not have the shortcomings of the air-cooling heat dissipation. The liquid-cooling heat dissipation module comprises a cooling device and a cooling pipe connecting the cooling device. The cooling device and the cooling pipe are disposed on the cabinet. The cooling pipe is connected to a heat exchanger for a heat source. The heat exchanger has a chamber, in which a plurality of heat dissipation fins are set. Multiple passages are formed between these fins. The cooling liquid provided by the cooling device flows to the heat exchanger through the cooling pipe, and flows through the passages in the heat exchanger. The cooling liquid performs heat exchange with the fins when flowing through the passages. In this manner, the heat absorbed by the fins can be taken away by the cooling liquid.

However, when cutting the upper margin of these fins, cutting waste is easily filled in the passages. Furthermore, part of the cooling liquid will gasify to be smaller bubbles. It is difficult to get rid of these bubbles if the cutting waste is filled in the passages. In other words, the cutting waste filled in the passages may block the cooling liquid flowing and thus influences the heat dissipation efficiency.

SUMMARY OF THE INVENTION

In one aspect, a method for fabricating a heat exchanger is disclosed. The method comprises providing a substrate comprising a base portion and a processing portion on the base portion, and the processing portion having at least one groove extending along a grooving direction. The processing portion is skived for standing a plurality of fins arranged in parallel along the grooving direction, and the groove passes through each fin. The plurality of fins are milled along a processing direction for making a distance between a processing surface of each fin and a bottom surface of the base portion be smaller than or equal to a preset value, wherein the processing direction intersects with the grooving direction, and the processing surface is far away from the base portion.

In another aspect, a heat exchanger is disclosed. The heat exchanger comprises a base portion and a plurality of fins disposed on the base portion in parallel along a processing direction. Each fin has a processing surface which is disposed on one side of the fin far away from the base portion. The processing surfaces are sunken to form at least one groove, and the groove extends along a grooving direction which intersects with the processing direction. Furthermore, each fin has two upper valley sides at the groove. Two upper valley sides connect the processing surface, and the two upper valley sides and the processing surface form an obtuse angle.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure will become more fully understood from the detailed description given herein below for illustration only, and thus are not limitative of the present disclosure, and wherein:

FIG. **1** is a flowchart for fabricating a heat exchanger according to an embodiment of the disclosure;

FIGS. **2**A-**7**B show a fabricating process for a heat exchanger according to an embodiment of the disclosure;

FIG. **7**C shows a fabricating process for a heat exchanger according to another embodiment of the disclosure; and

FIG. **8** is a structure illustration of a heat exchanger according to another embodiment of the disclosure.

DETAILED DESCRIPTION

In the following detailed description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

The detailed characteristics and advantages of the disclosure are described in the following embodiments in details, the techniques of the disclosure can be easily understood and embodied by a person of average skill in the art, and the related objects and advantages of the disclosure can be easily understood by a person of average skill in the art by referring to the contents, the claims and the accompanying drawings disclosed in the specifications.

FIG. **1** is a flowchart for fabricating a heat exchanger according to an embodiment. In this embodiment, the heat exchanger may be used in a liquid cooling heat dissipation module which is disposed in a cabinet server. The heat exchanger dissipates the heat generated from heat sources in the cabinet server. The fabricating processes for the heat exchanger will be described as below.

Firstly, a substrate is provided. The substrate comprises a base portion and a processing portion on the base portion. The processing portion has an upper surface and the base portion has a bottom surface. That is, the upper surface is opposite to the bottom surface. The upper surface has at least one groove extending along a grooving direction (step **S1**).

Next, the processing portion is skived to form a plurality of fins in parallel standing on the base portion. The fins are disposed in parallel along the grooving direction. The groove passes through each fin. (step **S2**).

The fins are milled along a processing direction which intersects with the grooving direction to form a processing surface. The distance between the processing surface and the bottom surface is smaller than or equal to a preset value. Furthermore, each fin has two upper valley sides for forming the groove. The two upper valley sides connect the processing surface. Each upper valley side intersects with the processing surface to form an obtuse angle (step **S3**).

An upper casing is provided. The upper casing comprises an accommodating space. A liquid input and a liquid output are connected to the accommodating space (step **S4**).

The upper casing is assembled to the base portion. The fins are set in the accommodating space. Furthermore, the liquid input and the liquid output are set at the two opposite ends of the fins (step **S5**).

FIGS. **2**A-**7**B show a fabricating process for a heat exchanger according to an embodiment. The detailed process is set forth as below.

Firstly, as shown in FIG. **2**A, the substrate **100** is provided. The substrate **100** can be made of but not limited to metal, such as aluminum alloy. The substrate **100** can be made by aluminum extrusion, but the disclosure is not limited this way. The substrate **100** comprises a base portion **110** and a processing portion **120** on the base portion **110**. As shown in FIG. **2**B, the processing portion **120** has an upper surface **121** and the base portion **110** has a bottom surface **111**. The upper surface **121** is opposite to the bottom surface **111**. Furthermore, as show in FIG. **3**, the upper surface **121** has at least one groove **122** extending along the grooving direction d**1**. The groove **122** may be formed together with the substrate **100** by aluminum extrusion. Alternatively, the substrate **100** is firstly formed by aluminum extrusion, and the groove **122** is formed by milling. FIG. **3** shows two grooves **122**, but the number of the groove is not limited.

Next, the processing portion **120** is skived to form a plurality of fins **130** in parallel standing on the base portion **110**. More particularly, as shown in FIGS. **4**A-**4**C, firstly the processing portion **120** is cut by using a knife **30** along the cutting direction d**3** so as to form a fin **130**. The cutting direction d**3** and the upper surface **121** form an acute angle θ_1, as shown by FIG. **4**B. Then, the fin **130** is bended to stand on the base portion **110**, as shown by FIG. **4**C. A plurality of fins **130** are formed in the same way as the above. It can be seen from FIG. **4**C that the distance h**2** between the highest point of the fins **130** and the bottom surface **111** is greater than the distance h**1** between the upper surface **121** and the bottom surface **111**. The smaller the acute angle θ_1 is, the larger distance h**2** will be. That is, if the acute angle θ_1 is smaller, the height of the fins **130** will be larger. As a result, persons skilled in the art would obtain an expected height of fins **130** by adjusting the acute angle θ_1.

As shown by FIG. **5**A, the fins **130** are in parallel along the grooving direction d**1**. The grooves **122** are extending along the grooving direction d**1** and pass through each fin **130**. As shown in FIG. **5**B, two adjacent fins **130** have a passage **132** therebetween. Each fin **130** has a processing surface **131** far away from the base portion **110** and the processing surface **131** is to be milled. As shown in FIG. **5**C, on each side of the passage **132** are the upper valley side **122***a* and the lower valley side **122***b*. The two upper valley sides **122***a* connect the processing surface **131**. The upper valley side **122***a* and the processing surface **131** form a obtuse angle θ_2 as shown in FIG. **5**D. In this way, a steep slope can be prevented on the processing surface **131** when forming the groove **122**. Because of the structure of upper valley side **122***a* and the lower valley side **122***b*, chances for the waste during milling going into the groove **122** can be reduced. In addition, the lower valley side **122***b* extends from one end of the upper valley side **122***a* to the base portion **110**, and the upper valley side **122***a* is between the processing surface **131** and the lower valley side **122***b*. Also referring to FIG. **5**D, an angle θ_3 is formed between two upper valley sides **122***a*, and an angle θ_4 is formed between two lower valley sides **122***b*. The angle θ_3 is greater than the angle θ_4. Actually, the angle θ_3 is formed when two upper valley sides **122***a* extend to the base portion. In particular, if the angle θ_3 is bigger (i.e., the angle θ_2 is bigger), when milling the processing surface**131**, it is more difficult to accumulate the processing waste in the fins **130**. Furthermore, the fins **130** may have more heat dissipation area if the angle θ_3 is bigger. In the other hand, considering the same opening width of the groove **122**, if the angle θ_3 is bigger, the depth of the groove **122** is smaller. As a result, the groove **122** will not be formed at the bottom of the groove **122**. The bubbles at the bottom of the groove **122** cannot be removed and thus the heat dissipation efficiency will be influenced. Therefore, considering the heat dissipation and reducing accumulation of processing waste, in this embodiment, angles θ_3 and θ_4 are determined to reduce the accumulation of processing waste and remove the bubbles between the fins **130**. As such, desired heat dissipation efficiency can be obtained.

With reference to FIG. **5**D, in this embodiment, the groove **122** comprises a first groove **123** formed by two upper valley sides **122***a* and a second groove **124** formed by two lower valley sides **122***b*. The depth D**1** of the first groove **123** is smaller than the depth D**2** of the second groove **124**. In other words, the first groove **123** with bigger opening width can be designed a smaller depth D**1**. The second groove **124** with smaller opening width can be designed a bigger depth D**2**. The reasons for designing the depth D**1** smaller than the depth D**2** are the same as the above. That is, according to this depth design, a bigger heat dissipation area and desired heat dissipation efficiency can be obtained when reducing the accumulation of processing waste.

With reference to FIGS. **6**A and **6**B, the fins **130** are milled by a knife **32** along the direction d**2** which intersects with the direction d**1**. The maximum distance between the processing surface **131** and the bottom surface **111** is smaller than or equal to a preset value h**3**, where the value h**3** may be determined according to different requirements. In this way, the height of the fins **130** can be controlled within a certain range to avoid interference with other elements (e.g. the upper casing **200** in FIG. **7**A) when assembly. In addition, here the direction d**2** is not exactly perpendicular to the direction d**1**. Under appropriate processing errors, the angle between the direction d**1** and the direction d**2** is regarded as a right angle.

In this embodiment, the obtuse angle θ_2 is formed between the upper valley side **122***a* and the processing surface **131**, so that a steep slope can be prevented at the processing surface **131** when forming the groove **122**. In such a case, when cutting the fins **130** along the direction d**2**, the cutting waste is easily removed from the passages **132**.

With reference to FIG. **7**A, an upper casing **200** is provided. The upper casing **200** comprises an accommodating space **201**. A liquid input **210** and a liquid output **220** are connected to the accommodating space **201**.

The upper casing **200** is assembled to the base portion **110**. The fins **130** are in the accommodating space **201**. As shown in FIG. **7**B, the liquid input **210** and the liquid output **220** are at the opposite two ends of the fins **130**. The upper casing **210** completely covers the base portion **110**, but the disclosure is not limited this way. For example, as shown in FIG. **7**C, the upper casing **200** can be disposed on the base portion **110** and partly covers the base portion **110**.

In this embodiment, the upper casing **200** may be assembled to the base portion **110** by soldering, but the disclosure is not limited this way. In this embodiment, the processing surface **131** is substantially attached to the upper casing **200** so that better heat dissipation efficiency can be achieved. The term "substantially" means due to processing errors the processing surface **131** may be approximately attached to the upper casing **200**. When the cooling liquid comes into the accommodating space **201** from the liquid input **210**, that the processing surface **131** is substantially tightly attached to the upper casing **200** avoids a gap from which the cooling liquid flows away. Without the gap between the processing surface **131** and the upper casing **200**, the cooling liquid can sufficiently contact with the fins **130** to prevent reducing heat dissipation efficiency.

With reference to FIGS. **7**A and **7**B, the heat exchanger **10** may be fabricated by the above mentioned process. The heat exchanger **10** comprises the base portion **110** and a plurality of fins **130**. The base portion **110** has the bottom surface **111**. The fins **130** are disposed in parallel on the side far away from the bottom surface **111**. Each fin **130** has a processing surface **131** far away from the base portion **110**. The processing surfaces **131** are cut to form at least one groove **122**. Each groove **122** extends along the grooving direction d**1**. The upper valley side **122***a* connects the processing surface **131**, and they form an obtuse angle.

In addition, in this embodiment, the heat exchanger **10** further includes an upper casing **200**. The upper casing **200** comprises an accommodating space **201**. A liquid input **210** and a liquid output **220** are connected to the accommodating space **201**. The upper casing **200** is assembled to the base portion **110**. The fins **130** are in the accommodating space **201**. The liquid input **210** and the liquid output **220** are set at two opposite ends of the fins **130**. The processing surface **131** is substantially attached to the upper casing **200**.

With reference to FIG. **8**, FIG. **8** is a structure illustration of a heat exchanger according to another embodiment. In other embodiments, the groove **122** may only comprise two upper valley sides **122***a* which connect to the processing surface **131** and form an obtuse angle with the processing surface **131**. However, the disclosure is not limited by these embodiments.

According to the above embodiments of the heat exchangers and method for fabricating the heat exchangers, the processing surfaces sunken to form grooves. The upper valley side of a groove and the processing surface form an obtuse angle. When cutting fins along a processing direction, the cutting waste can be easily removed and does not stuff the passage between fins. Furthermore, small bubbles brought by cooling liquid can be easily removed and thus the heat dissipation efficiency can be improved.

What is claimed is:

1. A method for fabricating a heat exchanger, comprising:

providing a substrate, the substrate comprising a base portion and a processing portion on the base portion, the processing portion having at least one groove extending along a grooving direction;

skiving the processing portion for standing a plurality of fins arranged in parallel along the grooving direction, the groove passing through each fin; and

milling the plurality of fins along a processing direction for making a distance between a processing surface of each fin and a bottom surface of the base portion being smaller than or equal to a preset value, wherein the processing direction intersects with the grooving direction, and the processing surface is far away from the base portion,

wherein the groove has two upper valley sides and two lower valley sides, the two upper valley sides connect the processing surface, each of the two upper valley sides forms an obtuse angle with the processing surface, one end of each of the two lower valley sides connects to corresponding one of the two upper valley sides, each of the two upper valley sides is between corresponding one of the two lower valley sides and the processing surface, the two upper valley sides form a first angle, the two lower valley sides form a second angle, and the first angle is greater than the second angle.

2. The method according to claim **1**, wherein after the step of milling the plurality of fins the method further comprises:

providing an upper casing, the upper casing having an accommodating space, the accommodating space is connected to a input and a output; and

assembling the upper casing to the base portion, setting the plurality of fins in the accommodating space, the liquid input and the liquid output are disposed at opposite two ends of the plurality of fins, the plurality of processing surfaces are substantially attached to the upper casing.

3. The method according to claim **1**, wherein the step of skiving the processing portion further comprises:

cutting the processing portion along a direction which forms an acute angle with an upper surface of the processing portion to form a fin, wherein the base portion has a bottom surface, and the upper surface of the processing portion is opposite to the bottom surface; and

bending the fin to make it stand on the base portion.

4. The method according to claim **1**, wherein the groove has a first groove located between the two upper valley sides and a second groove located between the two lower valley sides, the depth of the first groove is smaller than the depth of the second groove.

5. The method according to claim **1**, wherein the substrate is fabricated by aluminum extrusion.

6. The method according to claim **1**, wherein the processing direction is substantially perpendicular to the grooving direction.

* * * * *